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EXECUTIVE SUMMARY

CHARACTERIZATION OF FLY ASH LEACHATES

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Multilevel core ash samples from Booth Quarry fly ash disposal site were subjected to standard leachate extraction shake tests using deionized water as extractant. Extracts were characterized in terms of major, minor and trace components, including uranium and radium-226. Interstitial water was displaced from each core sample and likewise examined in detail. Throughout the study, uranium was below the detection limit, and radium-226 was present at levels just above or else below its detection limit. Each of these two elements was consistently present at levels below Ontario MOE Drinking Water Objectives. No strong correlation could be found between aqueous concentrations of uranium or radium-226 and general background components.

job	file	date	report no.
740631-575-092	837.71	January 31, 1986	85-235-K

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To: Mr. F.J. Kee
Director of Research

CHARACTERIZATION OF FLY ASH LEACHATES

A. Golomb

Multilevel core ash samples taken at Booth Quarry fly ash disposal site were subjected to standard leachate extraction shake tests using deionized water as lixiviant. The leachates were analyzed for major, minor and trace components, including uranium and radium-226. Piper trilinear diagrams were constructed for each leachate to characterize general water quality. Interstitial water extracted from each ash core sample was likewise studied. In all water samples, uranium was below the detection limit, while radium-226 was found to be present at levels either just above or else below its detection limit. No strong correlation could therefore be found between aqueous concentrations of uranium or radium-226 and general background components. Recommendations are made for further study.

1.0 INTRODUCTION

Since 1975, in fulfilment of Ontario Ministry of the Environment (MOE) requirements, Ontario Hydro Chemical Research Department has carried out monitoring studies of ground waters sampled from fly ash disposal sites including Booth Quarry, Birchwood Park and, more recently, Canada Brick Quarry. While the general chemistry of ground water sampled at the above fly ash disposal sites has given no cause for alarm, it has for some time/1/ been recognized that special attention should be given to radium-226. Fly ash, in common with most minerals, contains traces of the radioactive elements uranium and thorium, which undergo complex decay sequences terminating in stable isotopes of lead. Radium-226 (half-life 1600 years) is an important member of the uranium decay sequence, and is the source of radon emanation (radon-222 has a half-life of 3.82 days).

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Levels of radium-226 in ground waters in the Toronto area have been reported/1/ to be generally <1 pCi/L. In 1983, the Ontario MOE published Drinking Water Objectives which recommend a maximum safe level for Ra-226 of 3 pCi/L/2/. Ontario Hydro Research Division tried in 1982 to determine low concentrations (down to 0.1 pCi/L) of Ra-226 in fly ash leachate using gamma-spectrometric analysis. Unfortunately, analytical problems were encountered in approaching this target detection limit within reasonable counting times. Recently, the analytical technique was improved by preconcentration using coprecipitation of the sulphates of radium-226 and barium followed by α-spectrometry, giving a practical detection limit of 0.1 pCi/L for Ra-226.

This report gives analysis of leachable Ra-226, uranium, and other components (major, minor and trace) of fly ash leachate present in multilevel core ash samples taken from Booth Quarry, Etobicoke.

2.0 EXPERIMENTAL

2.1 Ash Core Sampling

An auger hole, designated Borehole 6, was drilled at Booth Quarry ash disposal site (Figure 1) by Civil Research (Soils Section) personnel. Fly ash samples were removed from the auger flight at three depth intervals below datum, ie, at 1.52-3.05 m (5-10 ft), 4.57-6.10 m (15-20 ft) and 7.62-9.14 m (25-30 ft) depth. The water table level stood at 4.57 m (15 ft) below datum (Figure 2). To prevent moisture loss, the ash samples were stored in tightly sealed, heavy-gauge linear polyethylene double bags prior to examination by Chemical Research staff.

2.2 Laboratory Tests

The moisture content of each ash sample was determined by oven-drying at 105°C. Each ash sample was subjected to the leaching shake test procedure described by Ham et al/3/ as shown schematically in Figure 3. Deionized water was used as extractant.

The ABC sequence provides an indication of maximum concentrations of water-soluble species that can be attained in the leachate. Fresh solid was added to the liquid remaining from the previous shake test; the additions were made to give solid-to-liquid ratios of 1:10, 1:7.5, and 1:5 respectively, with partial leachate removal for analysis after each test. The ADE sequence yields information about the maximum amount of leachable material present in the solid. Sample D was obtained by adding fresh deionized water, at a solid-to-liquid ratio of

1:10, to the leached ash residue from test A, and sample E was obtained in similar fashion from the residue from test D. All of the leachate samples were passed through 0.45 µm Millipore HAWP series filters prior to analysis.

Samples for metals analysis were preserved by acidification with 5 mL "Ultrex" nitric acid per litre. Unacidified portions were used for determination of pH, alkalinity, total dissolved solids, silica, chloride, sulphate, total organic carbon, and boron.

Interstitial water was extracted from each of the core specimens by a high pressure displacement technique/4/. Multiple displacements were carried out on material from each core section to yield ~1 L of pore water necessary for Ra-226 analysis, plus another ~1 L for analysis of all of the other components combined.

3.0 RESULTS AND DISCUSSION

Detailed chemical analysis of the interstitial waters and of the ABCDE leaching tests are given in Tables I-III. Where data permits, calculated mass release of individual species, based on the ADE leaching sequence, are tabulated. Calcium and sulphate ions were relatively the most abundant leachable species throughout. Uranium concentrations were below the detection limit of 0.005 mg/L in all of the aqueous samples.

3.1 Interstitial Waters

The water table at Booth Quarry (Figure 2) cuts through Borehole 6 at the top of the middle core section (4.57-6.10 m depth). It is noteworthy that the deepest core section (7.62-9.14 m depth) had the highest interstitial water concentrations of sulphate, chloride, sodium and potassium - interpreted to reflect maximum field leaching at the deepest stratum. Calcium levels in the pore water remained relatively independent of core-section depth. As expected, elevated concentrations of solutes in the interstitial waters generally coincided with diminished levels of remaining extractable solutes in the fly ash as calculated from the ADE sequence. Based on major ion balances (Table IV) for the interstitial waters, a Piper trilinear diagram (Figure 4) was drawn, which shows that pore water in the shallow and intermediate core samples had dominance of alkaline earths and strong acid anions. The deeper core sample had a tendency toward dominance of alkali metal cations and strong acid anions. This reflects the marked increase (Table III) in sodium and potassium leached

from the ash deposited at the deeper stratum. Elevated levels of TOC found in the interstitial waters are attributed to residual displacement fluid, Periplex G62, which is an organic epoxy plasticizer.

In all three core-sample interstitial waters, radium-226 levels were below the detection limit of 0.1 pCi/L. Consequently, it is not possible to directly correlate radium-226 with general background chemical species present in any of the three core-sample interstitial waters. (As noted above, the same applies to uranium, also found to be below detection limit). Clearly the radium-226 levels are very much below saturation, and certainly well below the MOE's 1983 Drinking Water Objective /2/ of 3 pCi/L. Likewise, the uranium levels in interstitial water were well below the Drinking Water Objective /2/ of 0.02 mg/L.

3.2 Leaching Test Extracts

Major ion balances were calculated for the ABCDE extracts resulting from leaching tests carried out on the three core samples taken from Borehole 6 at Booth Quarry. The results are given in Tables V-VII. Piper trilinear diagrams were constructed (Figures 5-7) for each core sample. The A, B, and C extracts all showed dominance of alkaline earths and strong acid anions. The ADE sequences each showed a progressive shift toward and into the region of dominance of alkaline earths and weak acid anions, as sulphate and chloride were removed by leaching.

As was found for the interstitial waters, uranium was consistently below the detection limit of 0.005 mg/L, and well below the 1983 MOE Drinking Water Objective of 0.02 mg/L. Radium-226 levels were mainly either just above the detection limit of 0.1 pCi/L or else below it. The highest leachate extract level of radium-226, 0.78 pCi/L (Extract A, intermediate core sample) was still well below the MOE Objective level of 3 pCi/L. As seen from Tables I-III, extract radium-226 concentrations for the shallow core sample increased in the ABC sequence, but decreased for the intermediate and deeper core samples. The ADE sequence for the three core samples anomalously showed no progressive concentration decrease for radium-226. The maximum mass release of Ra-226 (Table II, intermediate core sample) was estimated to be 11 pCi/L. Other elements in the ash that, like radium-226, are members of Group IIA of the Periodic Table, eg, calcium, magnesium and strontium, showed expected general leaching trends, in terms of increasing concentrations in the ABC sequence and decreasing concentrations in the ADE sequence. Of the major anions, sulphate likewise showed the expected trend,

as generally did chloride, which, however, underwent an anomalous decrease in the ABC sequence for the shallow core sample.

4.0 CONCLUSIONS

Since levels of uranium in all interstitial water and aqueous extract samples were below the detection limit (0.005 mg/L) correlation of uranium with individual background chemical species is impossible. Likewise, radium-226 was present at levels generally just above or below the detection limit of 0.1 pCi/L. An important feature of both uranium and radium-226 levels is that throughout the study each was present at levels well below the Ontario MOE Drinking Water Objectives (1983).

5.0 RECOMMENDATIONS

Although the experimental results indicate no present problem related to levels of radium-226 or uranium in interstitial water or ash extracts from multilevel core samples taken from Booth Quarry fly ash disposal site, it would be of interest to be able to forecast future trends. It is recommended that further core samples be taken and examined at intervals of, say every five years to check whether any significant increase in levels of radium-226 or uranium has occurred.

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TABLE I

BOOTH QUARRY BOREHOLE 6: ANALYSIS OF ABCDE LEACH TEST EXTRACTS AND OF INTERSTITIAL WATER
(Core Depth 1.52 to 3.05 m)

Species	Shake Leach Tests (mg/L)*					Extractable Solutes by A, D, E (mg/kg)*	Interstitial Water (mg/L)
	A	B	C	D	E		
pH	9.7	9.4	9.4	10.5	10.4	...	9.5
Sp Conductivity (mS/m)	116	215	218	38	32	...	24.0
Alkalinity OH^-	5	5	14	22	27	509	44
as $CO_3^=$	37	52	55	44	46	1210	86
$CaCO_3$ HCO_3^-	<5	<5	<5	<5	<5	0	<5
SO_4	580	1250	1380	102	50	6309	1450
Cl	16.5	3.5	6.1	0.2	<0.1	143	34
NO_3	0.58	1.2	2.1	0.29	0.13	4	8.3
Ca	268	590	610	67	51	3428	620
Mg	0.71	1.7	2.6	0.09	0.05	5	4.4
Na	2.5	5.4	8.7	0.45	0.23	10	31
K	3.1	6.4	10	0.67	0.35	21	29
Ag	0.0002	0.0004	0.0008	<0.0002	<0.0002	0	0.0005
Al	5.5	4.3	3.6	10.0	9.0	242	3.6
As	0.036	0.058	0.066	0.022	0.020	1	0.052
B	4.5	7.9	11.9	2.9	2.5	82	24.6
Be	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0	<0.0002
Ba	<1	<1	<1	<1	<1	0	<1
Br	<0.1	<0.1	<0.1	<0.1	<0.1	0	<0.1
Cd	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0	<0.0001
Cr	<0.1	<0.1	<0.1	<0.1	<0.1	0	0.2
Cr (VI)	<0.1	0.04	0.06	<0.03	<0.1	0	0.31
Cu	<0.001	<0.001	<0.001	<0.001	<0.001	0	0.005
Fe	<0.05	<0.05	<0.05	<0.05	<0.05	0	<0.05
Hg	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0	<0.0002
I	<0.05	<0.05	<0.05	<0.05	<0.05	0	<0.05
Mn	<0.05	<0.05	<0.05	<0.05	<0.05	0	<0.05
Mo	<0.5	<0.5	<0.5	<0.5	<0.5	0	0.5
Ni	<0.005	<0.005	<0.005	<0.005	<0.005	0	<0.05
Pb	<0.002	<0.002	<0.002	<0.002	<0.002	0	<0.002
Se	0.036	0.058	0.066	<0.022	0.020	0	0.052
Sr	2.7	7.8	9.6	0.63	0.35	30	9.4
Ti	<0.5	<0.5	<0.5	<0.5	<0.5	0	<0.5
U	<0.005	<0.005	<0.005	<0.005	<0.005	0	<0.005
V	0.19	0.22	0.25	0.15	0.09	0	0.29
Zn	<0.02	<0.02	<0.02	<0.02	<0.02	0	0.02
TDS (105°C)	NA	NA	2320	209	140	0	1980
Total Sol SiO_2	2.3	1.7	0.7	3.5	3.9	96	1.5
Hardness (as $CaCO_3$)	673	1482	1536	168	128	8592	1568
TOC	<1	<1	<1	<1	<1	0	122†
Ra-226	0.12	0.15	0.22	0.15	0.13	4	<0.10

* Solute concentrations given in mg/L except for Ra-226, expressed in pCi/L. Extractable Ra-226 in pCi/kg.

† Elevated TOC attributed to residual organic displacement fluid (Periplex G62).

TABLE II

BOOTH QUARRY BOREHOLE 6: ANALYSIS OF ABCDE LEACH TEST EXTRACTS AND OF INTERSTITIAL WATER
(Core Depth 4.57 to 6.10 m)

Species	Shake Leach Tests (mg/L)*					Extractable Solutes by A, D, E (mg/kg)*	Interstitial Water (mg/L)
	A	B	C	D	E		
pH	10.3	9.9	9.8	10.7	10.7	...	9.4
Sp Conductivity (mS/m)	70	127	185	43	40	...	250
Alkalinity OH^-	14	12	15	32	34	791	20
as $CO_3^=$	39	44	46	48	45	1280	89
$CaCO_3$ HCO_3^-	<5	<5	<5	<5	<5	0	<5
SO_4	310	650	1100	95	62	3985	1480
Cl	1.6	3.5	5.9	0.1	0.2	0	45
NO_3	0.17	0.17	0.56	0.15	0.09	1	5.7
Ca	142	300	480	61	50	2234	640
Mg	0.17	0.46	0.85	0.02	<0.02	1	2.2
Na	2.8	5.9	9.9	0.49	0.21	10	55
K	3.9	8.0	13.0	1.2	0.6	35	47
Ag	<0.0002	<0.0002	0.0003	<0.0002	<0.0002	0	0.0005
Al	7.0	5.0	3.0	15.0	11.0	0	2.4
As	0.030	0.034	0.041	0.030	0.027	1	0.030
B	3.3	6.2	9.5	3.0	2.5	80	17.8
Be	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0	<0.0002
Ba	<1	<1	<1	<1	<1	0	<1
Br	<0.1	<0.1	<0.1	<0.1	<0.1	0	<0.1
Cd	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0	<0.0001
Cr	<0.1	<0.1	<0.1	<0.1	<0.1	0	<0.1
Cr (VI)	0.05	0.03	<0.10	<0.02	<0.05	0	0.38
Cu	<0.001	<0.001	<0.001	<0.001	<0.002	0	0.002
Fe	<0.05	<0.05	<0.05	<0.05	<0.05	0	0.15
Hg	<0.0002	<0.0002	<0.0002	<0.0002	0.0004	0	<0.0002
I	<0.05	<0.05	<0.05	<0.05	<0.05	0	<0.05
Mn	<0.05	<0.05	<0.05	<0.05	<0.05	0	<0.05
Mo	<0.5	<0.5	<0.5	<0.5	<0.5	0	1.0
Ni	<0.005	<0.005	<0.005	<0.005	<0.005	0	<0.005
Pb	<0.002	<0.002	<0.002	<0.002	<0.002	0	<0.002
Se	0.030	0.034	0.041	0.030	0.027	1	0.030
Sr	1.78	4.1	7.6	0.74	0.49	26	8.5
Ti	<0.5	<0.5	<0.5	<0.5	<0.5	0	<0.5
U	<0.005	<0.005	<0.005	<0.005	<0.005	0	<0.005
V	0.12	0.16	0.19	0.09	0.06	3	0.15
Zn	<0.02	<0.02	<0.02	<0.02	<0.02	0	0.02
TDS (105°C)	NA	NA	1860	210	190	0	NA
Total Sol SiO_2	2.9	2.2	1.8	4.6	4.5	119	2.7
Hardness (as $CaCO_3$)	356	752	1203	153	125	5595	1609
TOC	<1	<1	<1	<1	<1	0	54†
Ra-226	0.78	0.49	<0.10	0.18	0.18	11	<0.10

* Solute concentrations given in mg/L except for Ra-226, expressed in pCi/L. Extractable Ra-226 in pCi/kg.

† Elevated TOC attributed to residual organic displacement fluid (Periplex G62).

TABLE III

BOOTH QUARRY BOREHOLE 6: ANALYSIS OF ABCDE LEACH TEST EXTRACTS AND OF INTERNATIONAL WATER
(Core Depth 7.62 to 9.14 m)

Species	Shake Leach Tests (mg/L)*					Extractable Solutes by A, D, E (mg/kg)*	Interstitial Water (mg/L)
	A	B	C	D	E		
pH	9.5	9.1	9.1	9.7	9.5	...	9.1
Sp Conductivity (mS/m)	95	180	260	20	90	...	460
Alkalinity OH^-	<5	<5	<5	<5	<5	0	23
as $CO_3^=$	33	40	54	26	19	729	112
$CaCO_3$ HCO_3^-	2	7	5	6	10	180	<5
SO_4	410	970	1550	48	11	3596	2400
Cl	9	14	12	0.3	<0.1	29	141
NO_3	0.13	0.08	0.04	0.01	0.14	3	0.01
Ca	170	400	590	30	14	1894	540
Mg	1.08	2.4	4.6	0.16	0.09	9	10
Na	23	44	83	1.?	0.6	4	550
K	13	27	51	2.1	0.93	42	260
Ag	<0.0002	0.0002	0.0005	<0.0002	<0.0002	0	0.0005
Al	3.0	2.3	1.5	3.8	3.5	102	1.4
As	0.016	0.016	0.015	0.016	0.019	1	0.012
B	4.4	8.1	11.7	1.7	<0.5	43	39
Be	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0	<0.0002
Ba	<1	<1	<1	<1	<1	0	<1
Br	0.7	1.6	2.5	<0.1	<0.1	6	1.7
Cd	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0	<0.0001
Cr	<0.1	<0.1	<0.1	<0.1	<0.1	0	<0.1
Cr (VI)	<0.03	<0.02	<0.10	<0.02	<0.02	0	<0.04
Cu	0.001	<0.001	0.013	<0.001	<0.001	0	0.002
Fe	<0.05	<0.05	<0.05	<0.05	<0.05	0	0.15
Hg	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0	<0.0002
I	<0.05	<0.05	<0.05	<0.05	<0.05	0	<0.05
Mn	<0.05	<0.05	<0.05	<0.05	<0.05	0	<0.05
Mo	0.5	1.0	2.0	<0.5	<0.5	0	7
Ni	<0.005	<0.005	<0.005	<0.005	<0.005	0	<0.005
Pb	<0.002	<0.002	<0.002	<0.002	<0.002	0	0.002
Se	0.016	0.016	0.015	0.016	0.019	1	0.012
Sr	1.66	4.4	6.5	0.29	0.11	16	9.5
Ti	<0.5	<0.5	<0.5	<0.5	<0.5	0	<0.5
U	<0.005	<0.005	<0.005	<0.005	<0.005	0	<0.005
V	0.05	0.05	0.04	0.05	0.06	2	0.05
Zn	<0.02	<0.02	<0.02	<0.02	<0.02	0	0.04
TDS (105°C)	NA	NA	2610	170	120	-	4150
Total Sol SiO_2	2.1	1.8	1.3	2.?	2.7	73	2.0
Hardness (as $CaCO_3$)	429	1010	1494	76	35	4766	1391
TOC	<1	<1	<1	<1	<1	0	400†
Ra-226	0.17	0.10	0.11	<0.10	0.12	3	<0.10

* Solute concentrations given in mg/L except for Ra-226, expressed in pCi/L. Extractable Ra-226 in pCi/kg.

† Elevated TOC attributed to residual organic displacemnt fluid (Periplex G62).

TABLE IV

MAJOR ION CHEMISTRY
INTERSTITIAL WATERS

CATIONS														
Depth (m)	Ca			Mg			Na			K			Cation Total (EPM)	Anion Total (EPM)
	mg/L	EPM	% EPM	mg/L	EPM	% EPM	mg/L	EPM	% EPM	mg/L	EPM	% EPM		
1.52-3.05	620	31	92.67	4.4	0.36	1.08	31	1.35	4.03	29	0.74	2.22	33.45	33.77
4.57-6.10	640	32	89.44	2.2	0.18	0.51	55	2.39	6.68	47	1.21	3.37	35.78	34.28
7.62-9.14	540	27	46.23	10	0.82	1.41	550	23.91	40.95	260	6.67	11.41	58.40	56.67

ANIONS											
Depth (m)	Cl			SO_4			Total Alkalinity (HCO_3^-, $CO_3^=$, OH^-) as $CaCO_3$			Anion Total (EPM)	Cation Total (EPM)
	mg/L	EPM	% EPM	mg/L	EPM	% EPM	mg/L	EPM	% EPM		
1.52-3.05	34	0.96	2.84	1450	30.21	89.46	130	2.6	7.70	33.77	33.45
4.57-6.10	45	1.27	3.70	1480	30.83	89.94	109	2.18	6.36	34.28	35.78
7.62-9.14	141	3.97	7.01	2400	50	88.23	135	2.70	4.76	56.67	58.40

Note: EPM denotes equivalents per million

TABLE V

EXTRACTS (ABCDE SEQUENCE) MAJOR ION CHEMISTRY:
DEPTH 1.52-3.05 m

CATIONS														
	Ca			Mg			Na			K			Cation Total	Anion Total
Extract	mg/L	EPM	% EPM	mg/L	EPM	% EPM	mg/L	EPM	% EPM	mg/L	EPM	% EPM	(EPM)	(EPM)
A	268	13.40	98.20	0.70	0.06	0.42	2.50	0.11	0.80	3.10	0.08	0.58	13.65	13.39
B	590	29.50	98.21	1.70	0.14	0.47	5.40	0.23	0.78	6.40	0.16	0.55	30.04	27.28
C	610	30.50	97.25	2.60	0.21	0.68	9.00	0.39	1.25	10.00	0.26	0.82	31.36	30.30
D	67	3.35	98.59	0.10	0.01	0.24	0.50	0.02	0.64	0.70	0.02	0.53	3.40	3.45
E	51	2.55	99.10	0.05	0.00	0.16	0.23	0.01	0.39	0.35	0.01	0.35	2.57	2.50

ANIONS											
	Cl			SO_4			Total Alkalinity (HCO_3^-, $CO_3^=$, OH^-) as $CaCO_3$			Anion Total	Cation Total
Extract	mg/L	EPM	% EPM	mg/L	EPM	% EPM	mg/L	EPM	% EPM	(EPM)	(EPM)
A	16.50	0.46	3.47	580	12.08	40.25	42.00	0.84	6.27	13.39	13.65
B	3.50	0.10	0.36	1250	26.04	95.46	57.00	1.14	4.18	27.28	30.04
C	6.00	0.17	0.56	1380	28.75	94.89	69.00	1.38	4.55	30.30	31.36
D	0.20	0.01	0.16	102.00	2.13	61.58	66.00	1.32	38.25	3.45	3.40
E	0.00	0.00	50.00	50.00	1.04	41.64	73.00	1.46	58.36	2.50	2.57

Note: EPM denotes equivalents per million

TABLE VI

EXTRACTS (ABCDE SEQUENCE) MAJOR ION CHEMISTRY:
DEPTH 4.57-6.10 m

CATIONS														
Extract	Ca			Mg			Na			K			Cation Total (EPM)	Anion Total (EPM)
	mg/L	EPM	% EPM	mg/L	EPM	% EPM	mg/L	EPM	% EPM	mg/L	EPM	% EPM		
A	142	7.10	96.61	0.20	0.02	0.22	3.00	0.13	1.77	4.00	0.10	1.40	7.35	7.36
B	300	15.00	96.73	0.50	0.04	0.27	6.00	0.26	1.68	8.00	0.21	1.32	15.51	14.76
C	480	24.00	96.63	0.85	0.07	0.28	10.00	0.43	1.75	13.00	0.33	1.34	24.84	24.31
D	61	3.05	98.26	0.02	0.00	0.05	0.50	0.02	0.70	1.20	0.03	0.89	3.10	3.58
E	50	2.50	99.03	0.00	0.00	0.00	0.21	0.01	0.36	0.60	0.02	0.61	2.52	2.88

ANIONS											
Extract	Cl			SO_4			Total Alkalinity (HCO_3^-, $CO_3^=$, OH^-) as $CaCO_3$			Anion Total (EPM)	Cation Total (EPM)
	mg/L	EPM	% EPM	mg/L	EPM	% EPM	mg/L	EPM	% EPM		
A	1.60	0.05	0.81	310	6.46	87.71	43.00	0.86	11.68	7.36	7.35
B	3.50	0.10	0.67	650	13.54	91.74	56.00	1.12	7.59	14.76	15.51
C	6.00	0.17	0.70	1100	22.92	94.29	61.00	1.22	5.02	24.31	24.84
C	0.10	0.00	0.08	95	1.98	55.25	80.00	1.60	44.67	3.58	3.10
E	0.20	0.01	0.20	62	1.29	44.89	79.00	1.58	54.91	2.88	2.52

Note: EPM denotes equivalents per million

TABLE VII

EXTRACTS (ABCDE SEQUENCE) MAJOR ION CHEMISTRY:
DEPTH 7.62-9.14 m

CATIONS														
Extract	Ca			Mg			Na			K			Cation Total (EPM)	Anion Total (EPM)
	mg/L	EPM	% EPM	mg/L	EPM	% EPM	mg/L	EPM	% EPM	mg/L	EPM	% EPM		
A	170	8.50	85.65	1.10	0.09	0.91	23.00	1.00	10.08	13.00	0.33	3.36	9.92	9.50
B	400	20.00	87.71	2.40	0.20	0.87	44.00	1.91	8.39	27.00	0.69	3.04	22.80	21.54
C	590	29.50	84.70	5.00	0.41	1.18	83.00	3.61	10.36	51.00	1.31	3.75	34.83	33.81
D	30	1.50	90.89	0.20	0.02	1.00	1.90	0.08	5.01	2.00	0.05	3.11	1.65	1.65
E	14	0.70	92.42	0.10	0.01	1.09	0.60	0.03	3.44	0.90	0.02	3.05	0.76	0.81

ANIONS											
Extract	Cl			SO_4			Total Alkalinity (HCO_3^-,$CO_3^=$,OH^-) as $CaCO_3$			Anion Total (EPM)	Cation Total (EPM)
	mg/L	EPM	% EPM	mg/L	EPM	% EPM	mg/L	EPM	% EPM		
A	9.00	0.25	2.67	410	8.54	89.96	35.00	0.70	7.37	9.50	9.92
B	14.00	0.39	1.83	970	20.21	93.81	47.00	0.94	4.36	21.54	22.80
C	12.00	0.34	1.00	1550	32.29	95.51	59.00	1.18	3.49	33.81	34.83
D	0.30	0.01	0.51	48	1.00	60.66	32.00	0.64	38.82	1.65	1.65
E	0.00	0.00	0.00	11	0.23	28.32	29.00	0.58	71.68	0.81	0.76

Note: EPM denotes equivalents per million

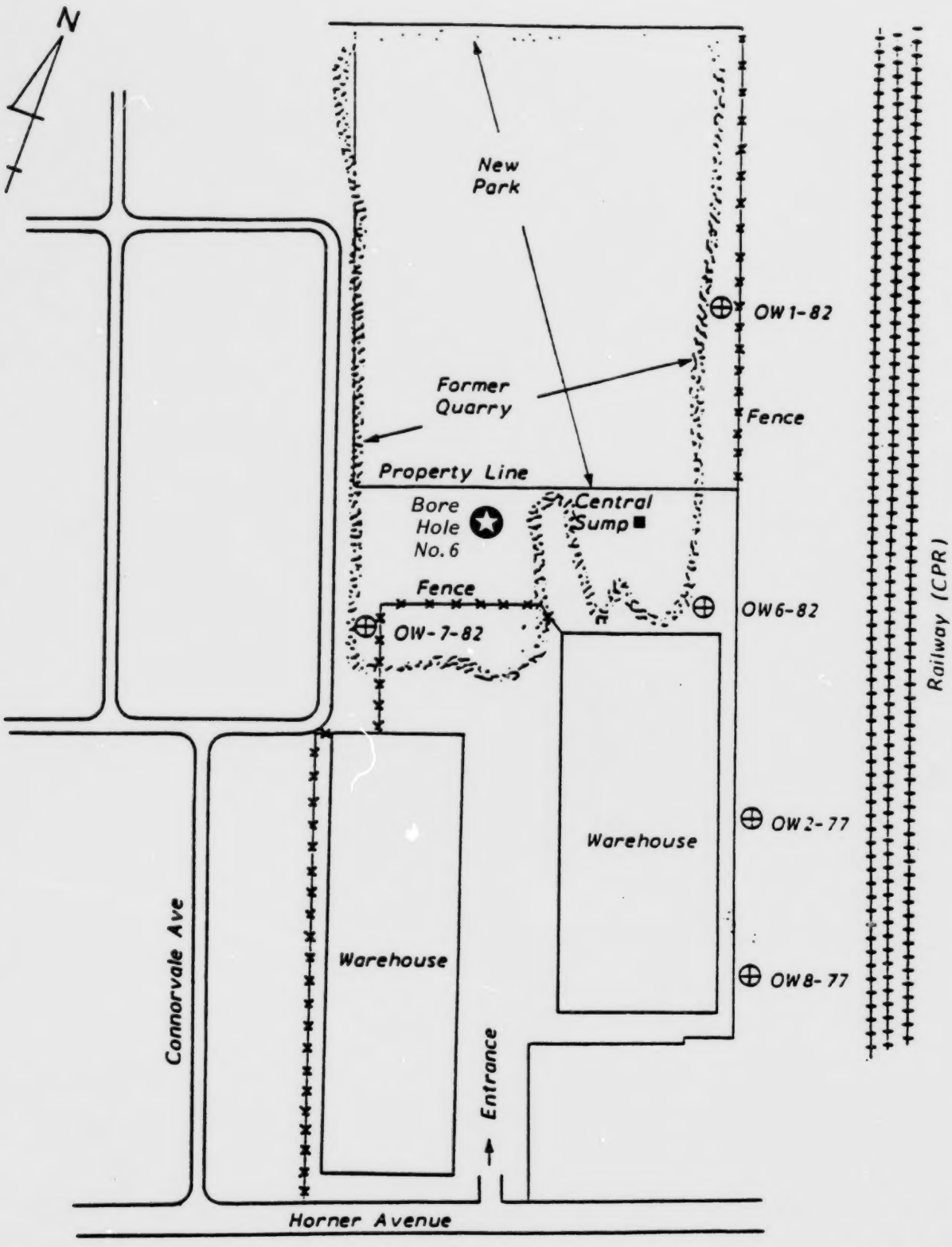

FIGURE 1

BOOTH QUARRY ASH DISPOSAL SITE
(Not to Scale)

169354 RD

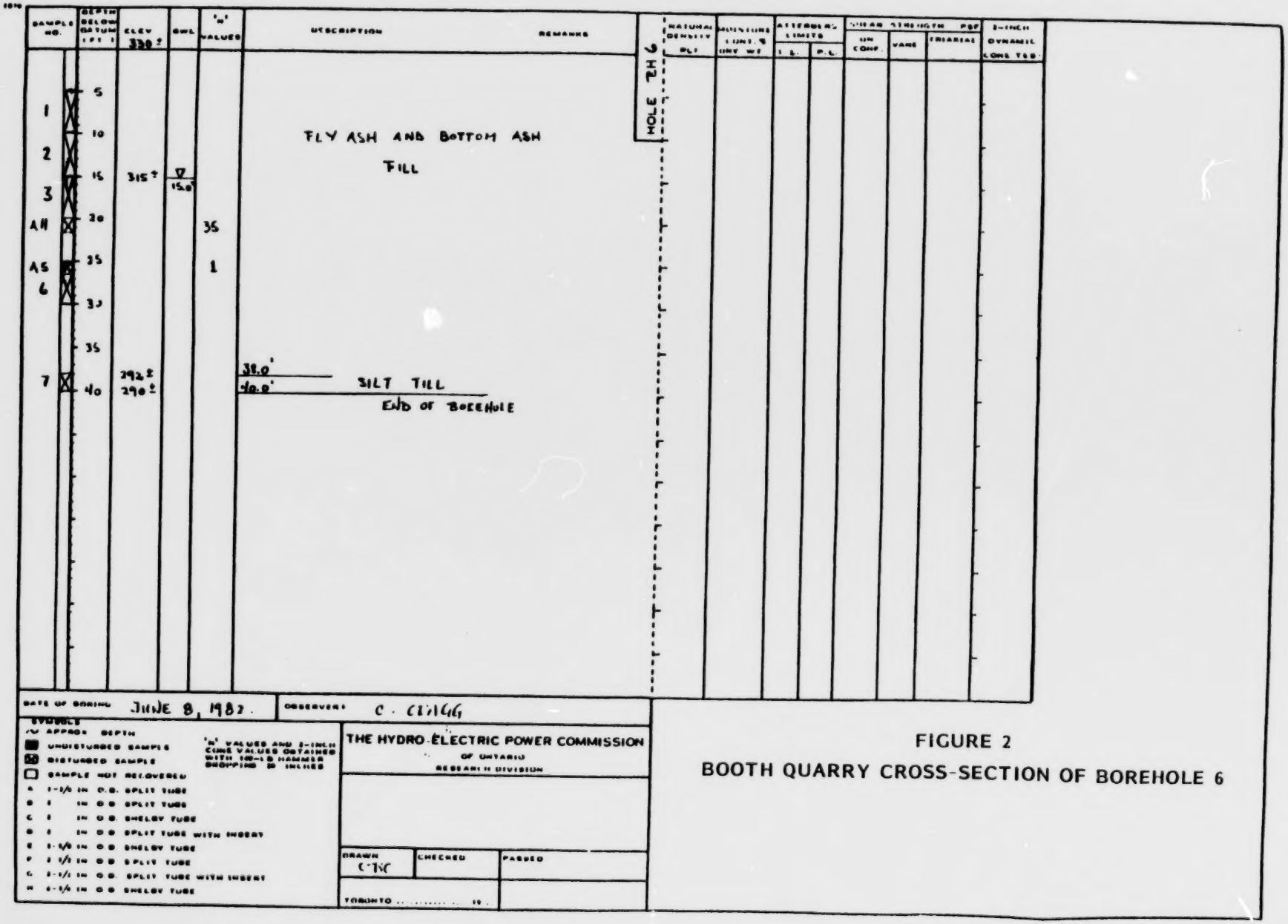

FIGURE 2

BOOTH QUARRY CROSS-SECTION OF BOREHOLE 6

169355 RD

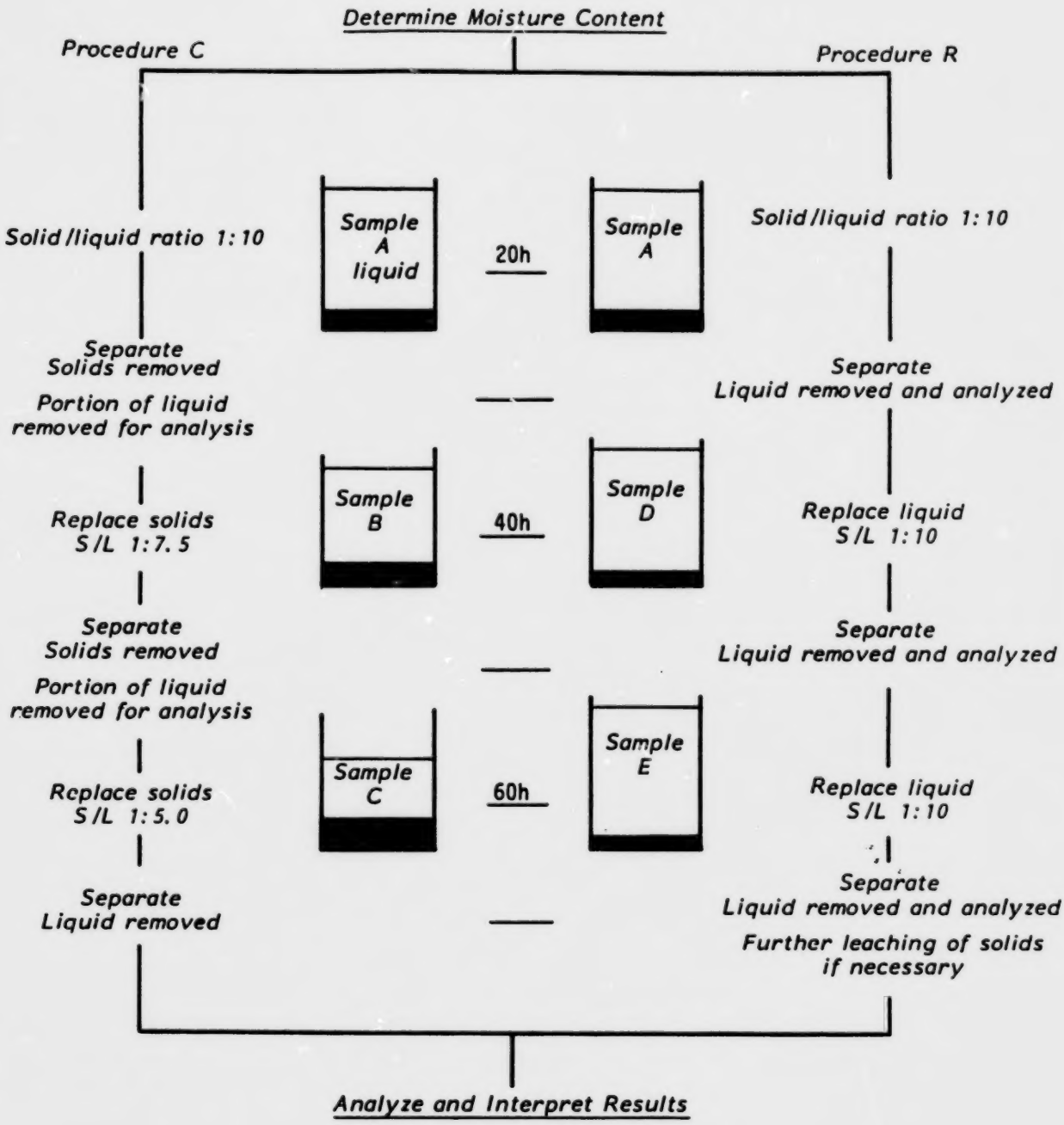

FIGURE 3

STANDARD LEACHING TEST FLOW SCHEME/3/

169356 RD

● 1.52 to 3.05m
■ 4.57 to 6.10m
▲ 7.62 to 9.14m

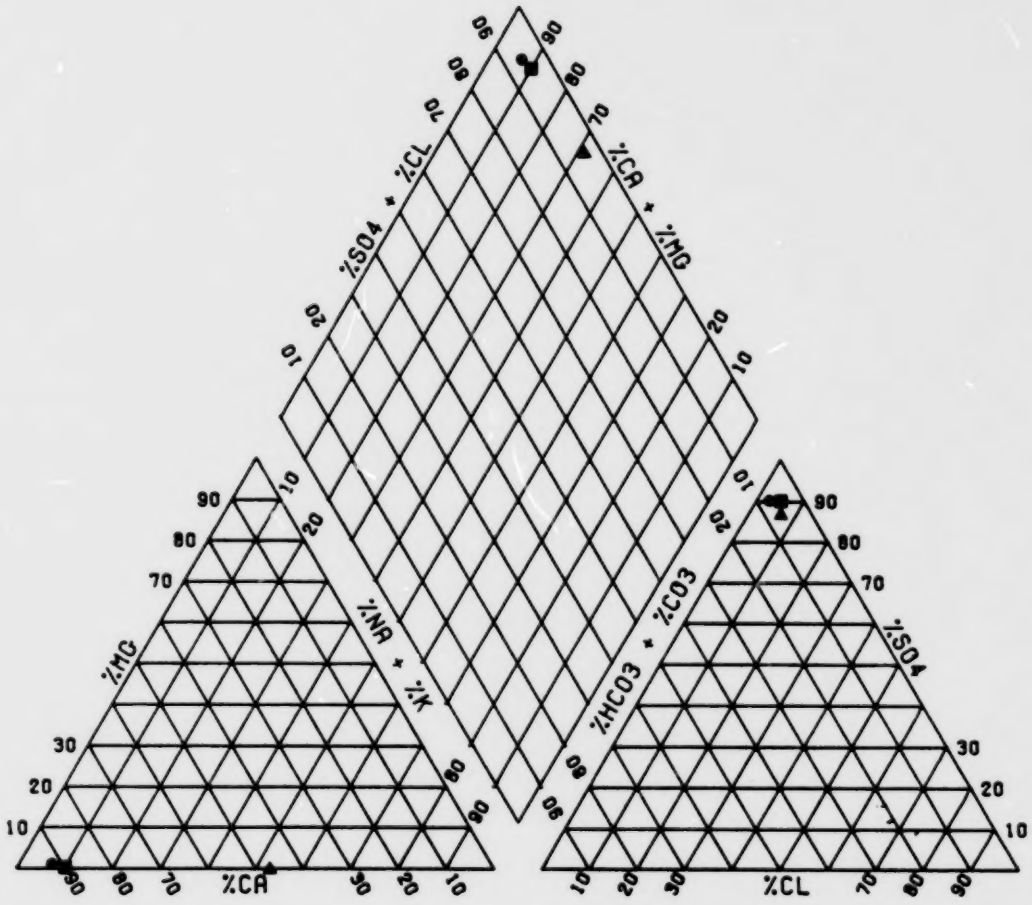

FIGURE 4

MAJOR ION CHEMISTRY
INTERSTITIAL WATERS

● Extract A
○ Extract B
■ Extract C
□ Extract D
▲ Extract E

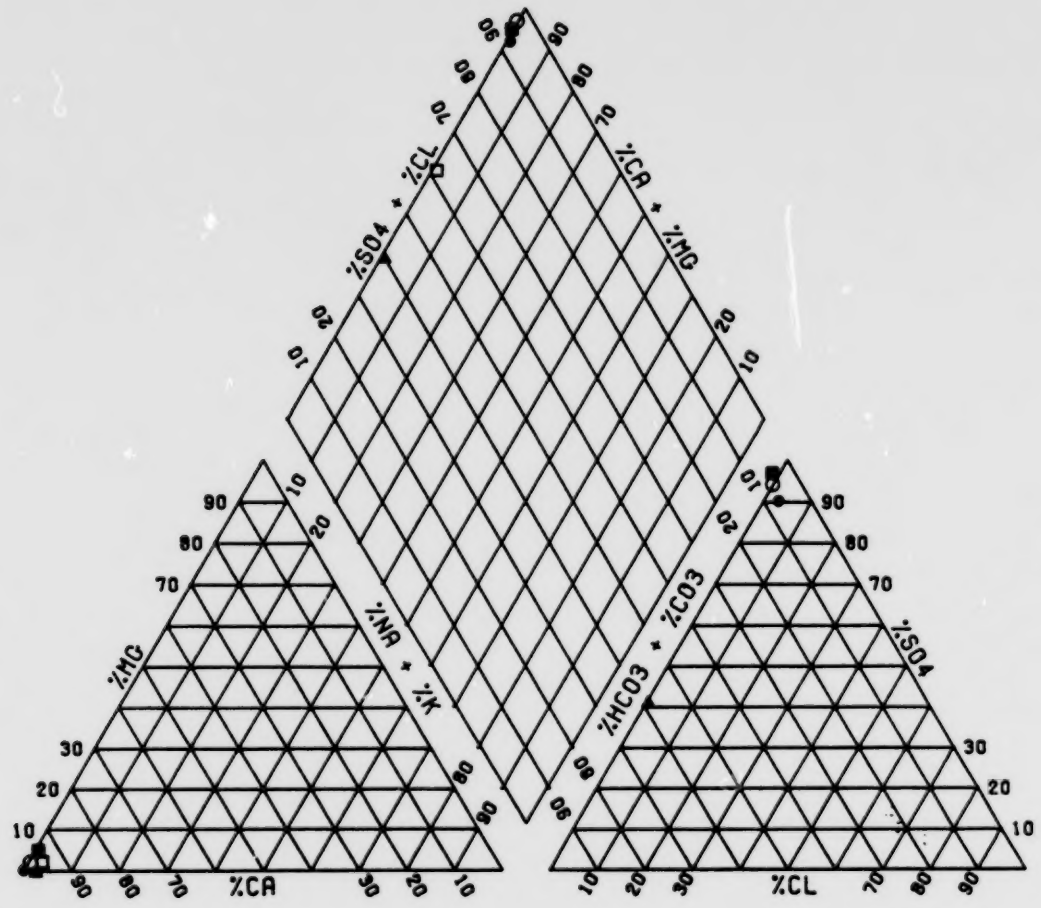

FIGURE 5

MAJOR ION CHEMISTRY
DEPTH 1.52 - 3.05m

● Extract A
○ Extract B
■ Extract C
□ Extract D
▲ Extract E

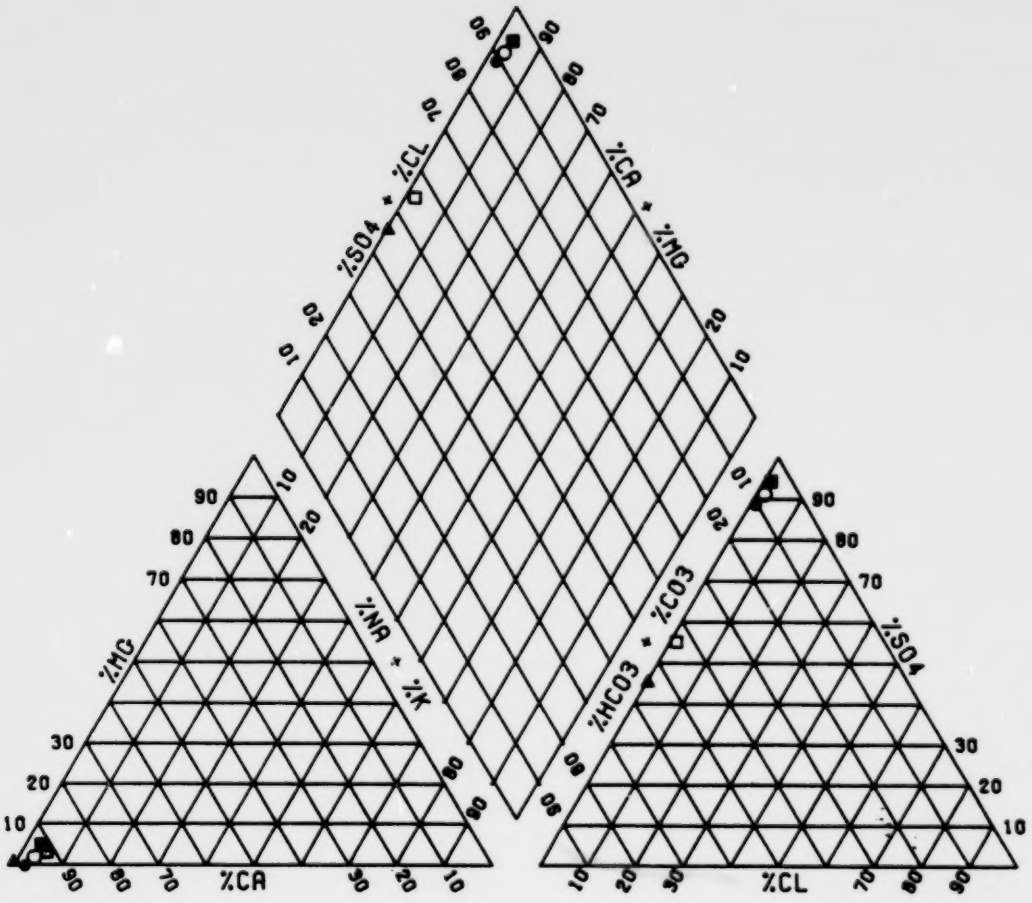

FIGURE 6

MAJOR ION CHEMISTRY
DEPTH 4.57 - 6.10m

- Extract A
- Extract B
- Extract C
- Extract D
- Extract E

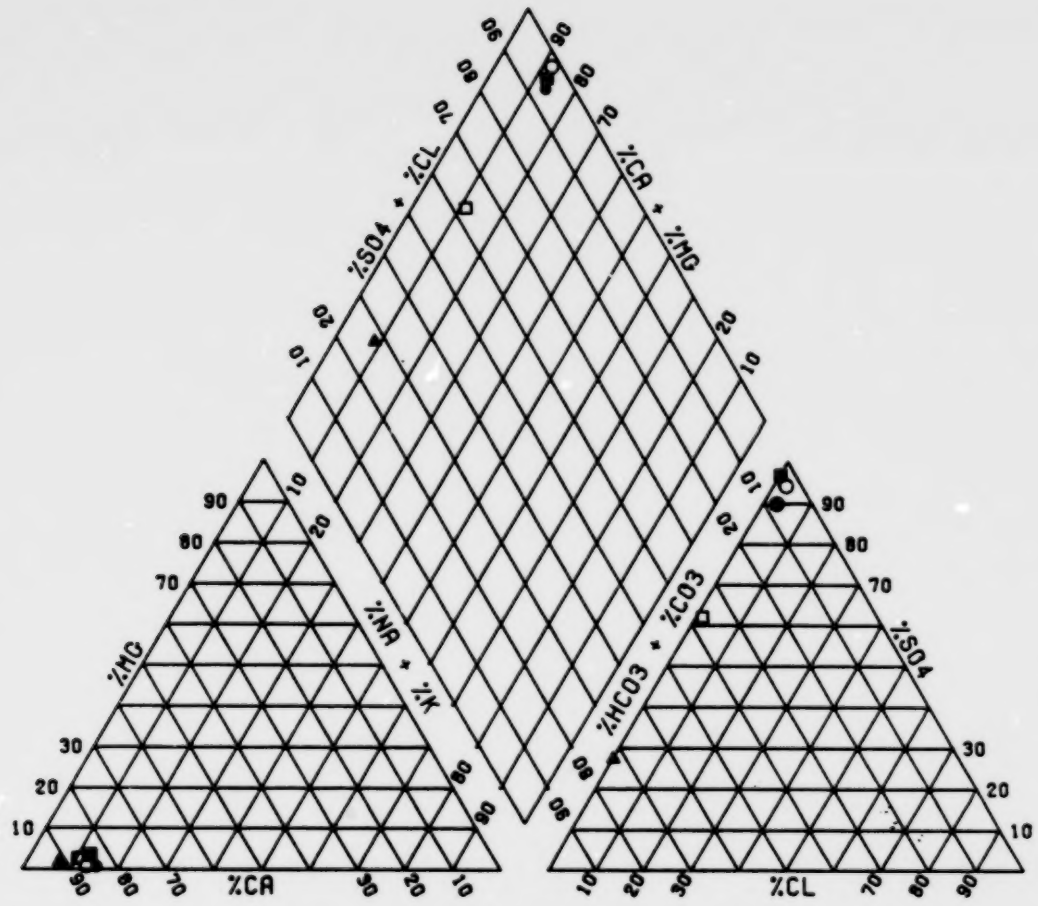

FIGURE 7

MAJOR ION CHEMISTRY
DEPTH 7.62 - 9.14m